THIS DOCUMENT COULD NOT
BE AUTHENTICATED AND HAS
BEEN PLACED IN THE FILE FOR
HISTORICAL PURPOSES ONLY
INITIAL DJ DATE 10/25/99

LETTER REPORT FOR UNEXPLODED ORDNANCE AND ORDNANCE EXPLOSIVES CLEANUP AT GOVERNMENT AND COMMERCIAL FACILITIES

March 1997

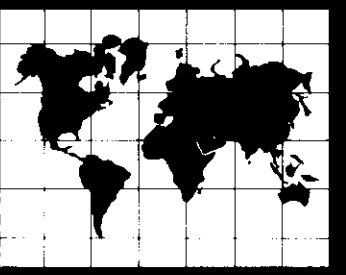
Prepared for
LMITCO ENVIRONMENTAL RESTORATION

Prepared by
SCIENTECH, Inc.
1585 North Skyline Drive
Idaho Falls, ID 83401
208-523-9552

CORPORATE HEADQUARTERS:

1690 INTERNATIONAL WAY

IDAHO FALLS, IDAHO 83402



EXECUTIVE SUMMARY

The purpose of this letter report is to present available information from a broad search for government and non-government sources that could be useful for determining both acceptable cleanup strategies and resulting costs that would be applicable at the INEEL regarding UXO and OE cleanup. The report summarizes information gathered from Department of Defense (DoD), Department of Energy (DOE), other government, and non-government sources.

The focus of the investigation was to find answers to the below eight questions.

1) Have UXO/OE cleanups with similar conditions to the INEEL been accomplished or are such cleanups ongoing?

While there is no single cleanup that is 100% applicable to the INEEL UXO/OE conditions, this search revealed pieces of useful information at various past and ongoing UXO/OE cleanups. Of the several hundred UXO/OE sites screened, this report presents information on 36 separate UXO/OE sites and deals with 14 sites in some detail.

2) What are the regulatory drivers for UXO/OE cleanups?

The DoD uses the Defense Environmental Restoration Program (DERP) as described in Section 160 of CERCLA as its regulatory authority for cleanup. The DoD uses Removal Actions (generally Non Time Critical) as described in the National Contingency Plan (NCP) as its guide for conducting UXO and OE cleanup.

Sandia National Laboratory (SNL), Los Alamos National Laboratory (LANL), and the Nevada Test Site (NTS), including the Tonopah Test Range (TTR), are DOE sites that are doing Environmental Restoration under RCRA programs. These sites are cleaning up UXO, in some cases voluntarily, as part of the Remedial Facility Investigation (RFI) prior to beginning corrective actions or clean closure.

Commercial cleanups are driven both by public concerns of safety and the need to eliminate deed restrictions so that property values are not affected by the potential to encounter a piece of UXO and are usually done voluntarily under local or state oversight.

Two current pieces of federal legislation are pending that affect UXO/OE. The Defense Range Rule as it is currently written will exclude the INEEL because there currently is a statutory agreement in place, the FFA/CO. However the Munitions Rule may apply to the INEEL. The Munitions rule was printed in the Federal Register on February 12, 1997. This rule deals with the question, "At what point does a munition become a RCRA waste and what waste management standards should apply for those munitions that are a hazardous waste?"

3) What were the future land use assumptions?

Land use was quite often mentioned as a lesson learned with the emphasis on establishing land use goals before beginning the cleanup. Because of the presence, type, and quantity of UXO on some DoD and BLM lands, these agencies have agreed that some areas may not be cleared. In uncleared areas, future land use will be restricted. Clearance of these areas is currently considered cost-prohibitive.

This research found very few cases where land that had once had UXO present was returned to public use without restrictions. Only at Tierrasannta and Mission Trails was any of the land returned for residential use and only after long and expensive cleanups were conducted.

Like the INEEL, future land use planning at the Nevada Test Site (NTS) has not been finalized. Department of Energy officials in Nevada are establishing an approach to embrace this concept by developing a site-wide Resource Management Plan. Since the NTS has some similarities to INEEL including similar topography, contaminants, and stakeholders such as Native Americans, the land use process at NTS may be useful in guiding INEEL land use planning activities.

4) What were the methods utilized for both characterization and remediation?

While new instruments and techniques are being developed, UXO/OE characterization and remediation will be most efficient and cost-effective via traditional methods that use standard hand-held magnetometers for locating geophysical anomalies, that is, the standard "Mag" and "Flag" clearance of UXO/OE.

Both LANL and TTP found it very cost effective to identify and remove UXO during the same field activity rather than flag the UXO for later removal.

One notable aspect of the UXO cleanup at TTR was the use of the Sandia National Laboratory RETRVIR system in the Bomblet Pit. The RETRVIR system uses a remote-control manipulator arm and various system-mounted, real-time video cameras to locate and pick up individual bomblets.

5) What were the screening concentrations and/or Remedial Action Objectives?

When UXO was present at a site, there were no clear guides to how clean is clean, or how much certainty of UXO removal is acceptable. The current risk assessment models do not adequately address the potential risks due to the wide dispersion of the debris and UXO.

Due to the difficulty of achieving 100% cleanup certainty of UXO at the Tierasanta site, a recommended corrective action was to keep educating Tierrasanta residents with respect to ordnance awareness. Signs and public awareness programs will likely be needed for any INEEL lands returned for public use.

LANL is attempting to achieve clean closure of its UXO sites by making the following statement in the *RFI Phase Report, Operable Unit 1071, SWMU Aggregate 0-D, Ordnance Impact Areas, March 1994:*

> **Given the extremely thorough UXO and OEW search and removal operation** and absence of any significant contaminants in the search and removal operation and absence of any significant contaminants in the soil or sediments, it is recommended that the site be designated as a NFA (No Further Action) PRS (Potential Release Site) and be approved for residential land use.

PRGs and RAOs for OE were not widely found. The best examples were contained in *Nonresidential Use Surface Soil, Subsurface Soil, and Groundwater PRGs* Table. Screening concentrations from this document are included in Section 5.2 of this report and may be useful in determining cleanup of TNT- and RDX-contaminated soils at INEEL.

6) What were the public comments, concerns and responses by the regulators?

This investigation did not turn up records of public comments either on Proposed Plans, or the public comments in the Non Time Critical Removal Action process. Records of Decision with Responsiveness Summaries that would be applicable to the INEEL were not found and Non Time Critical Removal Action public comments were not accessible from the USACE Huntsville.

7) What were the costs?

Because of its sensitive and proprietary nature, complete information is not fully available for most actual costs to compare work at sites. Even if the data was available, it is unlikely that it would be of much use in regards to the INEEL (or any other particular site). This statement is based on the cost information and studies done on past cleanups. This experience has shown that, depending on the identified site, UXO/OE remediation could take from several hours per acre to several days and resulting cost differences could be 400 times as expensive. The unknown extent of OE anomalies almost always drove costs far beyond government estimates.

One study was based on data from nine projects. The cost per acre for a removal action ranged from $94 to $36,642, depending on the type of work required.

Actual cost information is available from the USACE; however, this information is considered proprietary and confidential and is not released.

8) What are the lessons learned?

The sampling of random grids for both UXO and OE throughout a site is quite relevant to proper characterization. When done properly, random grid sampling can more precisely identify those areas that need thorough remediation and enable division of the site into sub-areas based on extent of contamination, as well as being instrumental in determining future land use. Considering the size of the INEEL, this could very well be applicable.

Changing site conditions affected characterization and remediation efforts. Reports on sweeps subsequent to a prior cleanup concluded with an admission that many more ordnance items were found, due to soil erosion factors and changing vegetation patterns.

Several cleanups including Tierrasanta Ordnance Removal cited that problems encountered would have been minimized if a more thorough investigation had been performed. The lesson learned here was that it is often more prudent to study the site, analyze various approaches to cleanup, realize there is not enough money to completely eliminate the ordnance risk, and learn to manage the risk.

Agency and stakeholder agreement early in the remedial process on future land use is key in determining necessary cleanup actions. Without a clear, well-defined land use to drive the remedial action objectives, both costs and/or safety to the public can be seriously affected.

Research presented here, as with most problems involving environmental remediation, indicates there was no "one site fits all" as a model. There certainly is not one "silver bullet" approach to characterization, clearance, or cost estimating when they involve UXO or OE. Characterization and remediation approaches for UXO and OE will rely heavily on a set of unique site-specific factors found only at the INEEL.

CONTENTS

TABLES

LETTER REPORT FOR UNEXPLODED ORDNANCE/ ORDNANCE EXPLOSIVES CLEANUP AT GOVERNMENT AND COMMERCIAL FACILITIES

1.0 INTRODUCTION

This letter report documents an extensive search for information and presentation of information that may be useful to plan and implement future actions in the remediation of Unexploded Ordnance/Ordnance and Explosives (UXO/OE) at the Idaho National Engineering and Environmental Laboratory (INEEL).

1.1 Purpose of the Letter Report

The purpose of this letter report is to present available information from a broad search for government and non-government sources that could be useful for determining both acceptable cleanup strategies and resulting costs that would be applicable at the INEEL regarding UXO/OE cleanup. The report summarizes information gathered from Department of Defense (DoD), Department of Energy (DOE), other government, and non-government sources.

The information search was focused on finding answers to the below questions:

1) Have UXO/OE cleanups with similar conditions to the INEEL been accomplished or are such cleanups ongoing?
2) What are the regulatory drivers for UXO/OE cleanups?
3) What were the future land use assumptions?
4) What were the methods utilized for both characterization and remediation?
5) What were the screening concentrations and/or Remedial Action Objectives?
6) What were the public comments, concerns, and responses by the Regulators?
7) What were the costs?
8) What are the lessons learned?

1.2 Brief History of UXO at INEEL

The INEEL was listed on the National Priority List (NPL) in 1989 as a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site. By being listed as an NPL site, regulatory requirements were invoked to clean up hazardous substances present on the site. The implementing document of CERCLA for the INEEL is a Federal Facility Agreement and Consent Order (FFA/CO) and requires DOE to perform response actions. Lockheed Martin Idaho Technologies Company (LMITCO) has been tasked by DOE to carry out the remedial response actions at the INEEL per the schedules defined in the FFA/CO Action Plan.

The FFA/CO designated all ordnance at the INEEL that were deposited during activities conducted at the Naval Proving Grounds (NPG) as Operable Unit (OU) 10-03. OU 10-03 was

established to ensure evaluation and remediation, if appropriate, of all explosive ordnance areas at the INEEL.

The NPG was established in 1942 to test-fire Naval guns, to conduct mass detonation tests, to practice aerial bombing, and to perform explosive material compatibility tests. As a result of the NPG activities, many projectiles (explosive and inert), explosive materials, ordnance explosive wastes (OE), and NPG structures and debris remain within the 890-square-mile area of the INEEL. Section 1.3 of this report presents a list of ordnance and contamination present from activities associated with the NPG.

Activities implementing the FFA/CO action plan for OU 10-03 included Track 1 and Track 2 Preliminary Scopings and various interim actions and removal actions conducted between 1992 and 1996. These activities are documented in *Preliminary Scoping Track 2 Summary Report for Operable Unit 10-03 Ordnance, February 1997.*

1.3 INEEL UXO/OE Sites and Descriptions

1.3.1 UXO/OE Sites Description

There are 29 identified UXO/OE sites located throughout the INEEL area. These sites can be categorized by type based on the activities conducted or suspected to have been conducted at each. The categories are bombing ranges, gun ranges, mass detonation areas, and disposal areas.

The bombing ranges are the Twin Buttes Bombing Range (TBBR) and the Arco High Altitude Bombing Range. UXO contamination primarily consists of the residue from M38A2 practice bombs. This residue can be classified as light, medium, or heavy. However, unexploded flare bombs were located during assessment activities in 1996. In addition, evidence of incendiary bombs was present on the Arco High Altitude Bombing Range. Other sites have shown evidence of high explosive bombs. But these bombs were more than likely transported versus air-dropped to the areas for disposal and/or testing. The Naval Ordnance Disposal Area (NODA) is an example of this.

The gun ranges can be identified as the areas where the Navy test-fired the refurbished "Gun" barrels during WWII and Vietnam. This was primarily done in the CFA 633, which consists of the Naval Firing Site and Down Range Area. All projectiles determined to have been fired during this testing contained no explosive hazards and ranged from 3 in. to 16 in. in diameter. Many live projectiles have been located on the INEEL but, as in the case with the bombs discussed earlier, they were not fired into the areas but were transported for disposal and/or testing.

The mass detonations areas were used to determine the effects of different explosives and ordnance items under different conditions, i.e., bunker tests, rail car detonation, mass detonations. As a result of the tests, these areas are contaminated with pieces of bulk explosives, unexploded projectiles, and their related components, landmines and fuzes. The Naval Ordnance Disposal Area (NODA), the National Oceanic and Atmospheric Association (NOAA) Area, the

Railcar Explosion Area, and the Landmine and Fuze Burn Area are all examples of this. All contain explosive hazards.

The disposal areas consist mainly of the NODA and the Mass Detonation Area. Though there is evidence that disposal had taken place at such areas as the NOAA and the Anaconda Power Line, these were the primary disposal sites. The NODA was used throughout the NPG era and is contaminated with live projectiles, remnants of live bombs, and bulk explosives. The Mass Detonation Area was selected as a disposal site in 1993 and has been utilized by UXO contractors since then to dispose of all UXO/OE recovered since remediation activities started.

1.3.2 UXO/OE Description

Table 1-1 below provides a brief description of the UXO/OE items that have been confirmed as present on the INEEL.

In addition, there are components from the UXO items that are too numerous to list. Basically, they consist of nose fuses, tail fuses, auxiliary detonating fuses, boosters, bursters, and bulk explosives [mainly Composition A-3 and trinitrotoluene (TNT)].

1.4 Methodology

Slightly different methodologies were used to cover the three major areas researched, i.e., DoD, DOE, and miscellaneous sites.

1.4.1 Department of Defense Sites

The methodology for obtaining information for DoD sites focused on three general tasks: document review; personal contacts with key staff at the U.S. Corps of Engineers (USACE), other government agencies, and private companies to obtain verbal input and documents; and searches of electronic databases via the Internet to determine what pertinent documents were available and to download available documents.

To implement the methodology, the project staff first thoroughly reviewed pertinent documents such as the 10-03 Track 2 Investigation, Sitewide Ordnance Assessment at the Idaho National Engineering Laboratory Scope of Work, dated May 16, 1996; the U.S. Army Corps of Engineers (USACE) Archives Search Report, dated May 1996; and former contractors' work plans.

Second, the U.S. Army Engineering and Support Center, Huntsville, Alabama, where the Ordnance and Explosives Center of Expertise and Design is located, provided input. Verbal contacts there included Ms. Wanna Griffit; Mr. David Douthat, Director, Ordnance & Explosives Directorate; and Mr. C. Robert Britton, Program Manager of the Unexploded Ordnance/Ordnance Explosive (UXO/OE) Department. Mr. Britton advised that they are currently developing a UXO/OE Project Database that would be utilized for cost comparison,

Table 1-1 Description of UXO/OE items found at the INEEL.*

UXO/OE Type	Nomenclature	Explosive		Fuze			Total Wt (lb) Approx.
		Filler	Wt (lb)	Nose	ADF	Tail	
Bomb Practice	M38A2	Black Powder	3	NA**	NA**	M1A1	100
Bomb Incendiary	AN-M52	Magnesium Alloy and Thermate	not available	NA**	NA**	Primer	2
Bomb Flare	M26	Flare Comp	not available	M111	NA**	NA**	53
Bomb GP	AN-M43	Amotol or TNT	264.5 280	M103	NA**	AN-M101	500
Bomb Demo	M32	Amotol or TNT	319.3 336	M103	NA**	AN-M101	600
Bomb SAP	M58	Amotol or TNT	154 159	M103	NA**	AN-M101	500
3-in. HE Projectile	Mk 31	A-3	.55	Mk 45	Mk 44	NA**	12.9
3-in. HE Projectile	Mk 33	A-3	.99	NA**	Mk 54	NA**	13.4
5-in. 38-cal Illumination	Mk 30	Blk Pwd Flare Magnesium	2.5 oz.	Mk 50	NA**	NA**	53
5-in. 38-cal WP	Mk 30	Blk Pwd Ballisite	2 oz. 14 grams WP 7.06	Mk 50	NA**	NA**	53
5-in. 38-cal AA Common	Mk 31	Exp-D Comp A	7.25 7.25	Mk 53	Mk 44	NA**	55.12
5-in. 38-cal AA Common	Mk 35	Exp-D	7.25	Mk 50	Mk 44	Mk 28	55.18
6-in. 47-cal Illumination	Mk 41	Blk Pwd Flare Magnesium	2.5 oz.	Mk 25	NA**	NA**	110
8-in. Projectile	Mk 22	Inert	NA**	NA**	NA**	NA**	277.1
8-in. AP Projectile	Mk 19	Exp-D	3.64	NA**	NA**	Mk 21	260
12-in. Projectile	Mk 19 Mod 1	Inert	NA**	Possible Tracer	NA**	NA**	1140
14-in. Projectile	Mk 17 Mod 2/3	Inert	NA**	Possible Tracer	NA**	NA**	1500
16-in. HC-PD	Mk 13	Exp-D	153.6	Mk 29	Mk 55	Mk 48	1900
16-in. Projectile	Mk 6 Mod 1	Inert	NA**	Possible Tracer	NA**	NA**	2240
16-in. Projectile	Mk 9 Mod 1	Inert	NA**	Possible Tracer	NA**	NA**	2700
Mine Anti-Tank	M1	TNT 6 Tetryl Booster	not available	M1A1	NA**	NA**	10.6

*This information was obtained from the following references: NAVSEA OP 1664, Ammunition Inspection Guide; TM 9-1900, Ammunition General; TM 9-1904, Ammunition Inspection Guide; and SW030-AA-MMO-010 Navy Gun Ammunition.

**NA = not applicable.

i.e., grubbing, target extract, UXO excavation, etc. This project database is not complete and no release date has been set.

Several Internet search engines and a large variety of general key words were used to access pertinent World Wide Web sites. The Defense Environmental Network and Information Exchange (DENIX) and several defense-related databases were identified The USACE Project Information Retrieval System (PIRS) proved to be the most comprehensive in content and usefulness for this report.

Using the PIRS database, a search identified 800 potential relevant documents in the database with similarities to the INEEL. A review and screening of the 800 documents produced about two dozen DoD "semi-finalist" facilities that showed the most promise of applicability to the INEEL and that would be reviewed in detail. These "semi-finalist" sites are listed in Table 2. The "finalist" sites are then discussed in detail Section 2.0. It is important to note that due to the complex nature of remediation of the sites presented, an extensive history is included so the reader can understand the "evolution" of the cleanup process.

The majority of DoD UXO/OE cleanups are controlled by the U.S. Army Ordnance and Explosives Center of Expertise and Design located in Huntsville, Alabama. The library at Huntsville holds the Engineering Evaluations and Cost Analyses (EE/CAs) and After Action Reports that include some of the information sought for this report. However, this information is considered proprietary by the USACE and access to most of the library files are strictly limited to its personnel.

1.4.2 Department of Energy Sites

The methodology employed to search for UXO/OE information on DOE facilities was via Internet searches of all DOE facilities. Over 100 DOE sites located in 32 states were identified. UXO/OE was identified at five of these DOE sites. Internet home pages were searched for technical information, as well as for program or project technical personnel contacts. E-mail messages and phone calls were repeatedly made to technical contacts to obtain specific information as outlined in Section 1.1. Some information was transmitted verbally over the phone, some information was received via Federal Express, and some of the promised information has not been received at the time of the preparation of this report.

1.4.3 Miscellaneous Sites and Information

Miscellaneous information includes the information found in Section 4.0, Miscellaneous Cleanups, and Section 5.0, UXO Identification and Field Screening. Information for Section 4.0 included an initial search of all Records of Decision (RODs) both at the EPA library in Washington D.C. and on several databases maintained by EPA, Unison Institute, and the OMB Watch. Non-DOE and non-DoD RODs were targeted for investigation; only seven RODs were identified; however, all of these dealt with cleanup of former ordnance manufacturing facilities, and there was little applicability to the INEEL. Searches did not yield a single data base or information source dedicated to or specific to EE/CAs. EPA Region 10 was contacted via phone

to obtain a list of cleanup actions in Pacific Northwest that may be applicable to INEEL conditions. Also information for cleanup at Chino Hills, California, and Garfield Flats, Nevada, was obtained by interviews with past site workers.

2.0 DEPARTMENT OF DEFENSE CLEANUPS

As discussed in Section 1.4, Methodology, this section is the result of a thorough search for former Department of Defense (DoD) UXO/OE cleanup sites. The list of sites was narrowed to those identified in Table 2-1 (at the end of Section 2). Sites in Table 2-1 were selected for similarities and potential applicability to the INEEL. From Table 2-1, project staff further investigated those sites thought to be most similar in terms of cleanup effort required compared to the INEEL. The following is a detailed description of the sites, namely, Tierrasanta Community (Section 2.1), Mission Trails Regional Park (Section 2.2), and Fort Ord (Section 2.3).

The DoD uses the Defense Environmental Restoration Program (DERP) as described in Section 160 of CERCLA as its regulatory authority for cleanup. One of the goals of the DERP program is the "correction of other environmental damage (such as detection and disposal of Unexploded Ordnance) which creates and imminent and substantial endangerment to the public health or welfare or to the environment." The U.S. Army Corps of Engineers (USACE) was designated as the executive agent for DoD in implementing the DERP program. The USACE uses Removal Actions (generally Non Time Critical) as described in the National Contingency Plan (NCP) as its guide for conducting UXO and OE cleanup.

There are currently two pieces of legislation pending that will greatly affect UXO/OE remedial activities in the future. The Department of Defense Range Rule is currently in draft form and will appear in the Federal Register in the spring of 1997. This rule, when final, is intended to define response actions to address the unique risks posed by military munitions and other associated materials on closed, transferred, and transferring military ranges. The Range Rule will designate DoD as the lead removal response authority with respect to Military Munitions under CERCLA (40 CFR 300.120(d)). However the rule is currently written to exclude transferred (like the INEEL) military ranges that are undergoing response activities pursuant to any agreements negotiated prior to the effective date of the rule. Since the INEEL is currently subject to the FFA/CO, it would be excluded from this rule.

The second piece of legislation, the Munitions Rule, was printed in the Federal Register on February 12, 1997. This rule deals with the question, "At what point does a munition become a RCRA waste and what waste management standards should apply for those munitions that are a hazardous waste?" This rule could affect the handling, transportation, and disposal of UXO/OE at the INEEL.

2.1 Tierrasanta Community

Environmental Chemical Corporation (ECC) was awarded a contract to perform "ordnance clearance" actions on that portion of the former DoD property, Camp Elliott, now called the Tierrasanta Community of San Diego, California.

2.1.1 Site Description

Camp Elliott became operational during World War I when the U.S. Army used it for artillery and machine gun training. The contract area was transferred to the U.S. Navy in 1941 and was home for several commands, including (a) the Fleet Marine Force Training Center, West Coast and (b) the Troop Training Unit of the Amphibious Training Command for the Pacific Fleet. The base provided encampments, bivouac areas, and 41 firing ranges. These ranges were used for tank training, anti-tank training, artillery training, demolition training, mines, raw explosives, and parachuting practice. Additionally, from 1941 to 1944, schools were formed there for infantry, scout, mortar, and sniper education. The base and ranges were used for training on every type of weapon in the Marine inventory until 1944, when they moved to Camp Pendleton. After the Marine move, the Navy continued to operate the base as the Training and Distribution Center until 1946, then the Retraining Command from 1947 until 1960.

When Camp Elliott closed in 1960, much of its land was doled out to different military services for ownership. The Navy declared 13,277 of the original 30,500 acres "excess" and transferred this area to the General Services Administration (GSA) for disposal. The "excess" was disposed of through land exchanges, grants, and sales, and San Diego City officials acquired much of it for public use and development.

Land sold to developers from the former Camp Elliott acquisitions included what is now the active and somewhat exclusive suburb of Tierrasanta. Homes and shopping centers occupy the canyon tops (mesas) that spread throughout the community.

Future land use planning includes residential, recreational, and educational facilities. Unrestricted recreational use, such as hiking and bicycling trails, already exist in most canyons where prior clearance operations took place.

2.1.2 Prior Clearance Efforts

There were four previous attempts at locating and removing ordnance from portions of Tierrasanta prior to ECC's contract. An ordnance sweep by both Navy and Marine Explosive Ordnance Disposal (EOD) units (one each) was conducted in the mid-1960's, but in 1983 a tragic mishap occurred. Three young Tierrasanta children were playing in one of the canyons near their homes when they found a object that was later confirmed to be an unexploded 37-mm round. According to accident investigators, one of the children beat on the munition in such a way as to allow its malfunctioning fuze to function, causing the round to detonate. Two of the children were killed by the explosion and the third seriously injured.

The accident raised public awareness, creating an outcry for action to rid the canyons of the UXO. The U.S. Navy EOD Mobile Unit Three performed two searches, one in 1984 and one in 1985, but it was obvious that a thorough search with magnetometers was necessary.

Like the past UXO sweeps, these done in the 1980's were mostly visual, due to thick brush which was not removed, precluding a thorough magnetic sweep. Electronic searches were restricted to roadways, paths, and trails. As a result, few items were found, compared to the large number of items recovered during ECC's contract. Additionally, not all of the Tierrasanta affected areas were covered; some sectors where facilities were built were not swept. The reports on these later sweeps concluded with an admission that many more ordnance items would be found, due to soil erosion factors and changing vegetation patterns. The recommended corrective action was to keep educating Tierrasanta residents with respect to ordnance awareness.

2.1.3 Reasons for Cleanup

During WWII and the Korean War periods, Camp Elliott was home to more than 250,000 troops performing maneuvers and gunnery training. Significant numbers of the fired projectiles, rockets, mortars, and other ordnance items failed to function as designed. The deaths of the two children in 1983, combined with the development on the former military property, brought an increase in public pressure to make the open space around dwellings safe. Clearances, both before and after the children's mishap, uncovered sufficient quantities of UXO to warrant further investigations into the amount of contamination remaining in the environs of Tierrasanta. A Feasibility Study of Remedial Action Alternatives, combined with an Environmental Impact Survey was performed in 1988. The preferred alternatives in the Feasibility Study made it apparent that no single alternative was appropriate for the entire project area. To facilitate comparison and analysis of alternatives, the open space within the project area was divided into sub-areas based either on present use, projected future use, or physical characteristics. The subsequent reports, statements, and associated documents were the basis for a Record of Decision (ROD), dated October 17, 1988. The ROD supported the combination of alternatives recommended by the previous documents. The land mass was divided into sub-areas to facilitate comparison and analysis of alternatives. The report and ROD proposed different actions be employed for the various sub-areas. Two sectors were parts of federal properties, so fencing in these lands to deny access was deemed the appropriate remedy. Based on the final objective to protect public health, safety, and welfare, the remaining four sub-areas, totaling 1,364 acres, received plans for ordnance clearance sweeps using electromagnetic locators.

2.1.4 Statement of Work (SOW)

The objective of the contract was to provide services for the removal of UXO and related debris contamination caused by previous DoD-related activities on a portion of the former Camp Elliott Training Range.

Electromagnetic ordnance locators capable of locating ordnance and ordnance debris to a depth of 3 ft were required to be used. A systematic approach whereby sub-areas were divided into search grids no greater than 100 ft by 200 ft was necessary. Records of

ordnance materials recovered were to be kept, and a map depicting the grids had to be maintained.

Diagnosis of UXO had to be performed by fully qualified UXO technicians. Items deemed OEW or UXO and safe to transport were to be moved to a safe holding area for removal by the 70th Ordnance Detachment (U.S. Army EOD unit positioned at the Point Loma U.S. Navy Facility). Those materials deemed not safe to move were to be marked and protective measures taken by ECC, as appropriate, until the USACE Contracting Officer or representative notified the 70th Ordnance Detachment, and the item was disposed of by detonation. OEW scrap was to be certified by a UXO technician as explosive-free and periodically removed from a collection point to the local Defense Reutilization and Marketing Office (DRMO).

2.1.5 Lessons Learned

Planning for the Tierrasanta Ordnance Removal project was formulated based on conclusions and recommendations cited in the initial assessment report for the Tierrasanta area. There is strong speculation among ECC project managers that some of the problems encountered during the formulation and conduct of the contract could have been averted if a more thorough investigation had been performed. A random sample formula was constructed from which test grids were chosen. This mathematical model probably might have, if followed, provided desired results. However, the random sequencing of performing tests was abandoned by those conducting the survey for a more convenient order. Instead of surveying the grids chosen by the random process, they apparently opted for grids in which vegetation was minimal and their topography was more comfortable to work.

In addition, there were problems encountered with ferrous metal trash. Ordnance debris in the form of fragmentation was tedious to remove. If a round had functioned (detonated) upon impact and/or after penetration into the ground, it usually fragmented into many small pieces. These bits never kept a uniform spread pattern. When technicians came across this situation, as they often did, they spent as much as 2 to 3 hours digging in one spot removing the pieces. This practice was required because live ordnance rounds had been found below existing fragmentation patterns. This was also the case in 1994 when the NODA at the INEEL was cleaned up.

To date, the USACE has removed more then 5,000 pieces of HE UXO from approximately 800 acres in the Tierrasanta Community. On June 7, 1994, the Tierrasanta ordnance removal action project was completed, and the USACE began focusing its cleanup efforts on Mission Trails Regional Park.

2.2 Mission Trails Regional Park

The Mission Trails Regional Park is part of the former Camp Elliott. The area is east of the community of Tierrasanta. The Tierrasanta historical background/former military use is the same for this site.

2.2.1 Project Description

As a result of a visual site inspection requested by the USACE on March 25, 1988, and conducted by Nasland Engineering, under contract to the Los Angeles District USACE, an ordnance removal project was proposed for this area. It was determined that, in order to perform an ordnance removal project, the site must be cleared enough to (a) visually inspect the surface and (b) use the subsurface metal detector equipment to scan to a depth of 3 ft below the surface.

2.2.2 Description of Site

The project site consists of approximately 2100 acres and is located on a portion of the former Camp Elliott. Except for the improvements within the utility easements and the aqueduct easement, the site is in its original state. The City of San Diego has acquired most of the land and is in the process of acquiring approximately 693 more acres. The land is being acquired from the Navy (680 acres) and the San Diego Unified School District (13 acres).

The area is posted to prohibit access by vehicles. However, the site is easily accessible to motorcycles and 4-wheel-drive vehicles. Evidence at the site and sightings indicted the site is used by motorcycles, 4-wheel-drive vehicles, and joggers.

2.2.3 Reason for Cleanup

From the records reviewed, there are no reports of any injury from the project site due to unsafe debris, hazardous or toxic waste, or ordnance. However, the City of San Diego Fire Department records indicated that, in 1984 and 1985, they responded and recorded eight military ordnance items found near Fortuna Mountain in the park. Since the U.S. Navy's 1983 explosive ordnance survey checked only the surface and this area has not been checked since, it is possible that erosion or rain has uncovered more ordnance.

2.2.4 Statement of Work

The objective of this contract was to safely conduct a surface/subsurface sweep of 25 1-acre plots for UXO to provide sampling data for future removal action.

Where brush clearance was required, surface sweeps of each grid were conducted prior to brush clearance operations. The interval between walking searchers did not exceed 12 ft.

A shorter interval may be required due to terrain, vegetation, and/or contamination density.

For each grid, subsurface sweeps to a depth of 3 ft were conducted with a Mk 26 Ordnance Locator. In the grids requiring brush clearance, the subsurface sweep was conducted after the specified brush clearance operations. Access to subsurface anomalies was done by use of non-sparking tools.

2.2.5 Lessons Learned

Using the method of sampling random grids throughout a site is quite relevant to proper characterization. When done properly, random grid sampling can more precisely identify those areas that need thorough remediation and enable division of the site into sub-areas based on extent of contamination, as well as being instrumental in determining future land use. Considering the size of the INEEL, this could very well be applicable.

2.3 Fort Ord, Multi-Range Area (MRA)

2.3.1 Site Description

Fort Ord is located along the Pacific Ocean in northern Monterey County, California. It occupies approximately 28,000 acres adjacent to Monterey Bay (a national marine sanctuary) and the cities of Marina, Seaside, Sand City, Del Rey Oaks, and Monterey.

2.3.2 Historical Background

Fort Ord was established in 1917 when the government purchased 15,809 acres near what is now the East Garrison Area. It was used as a maneuver area and field target range for the 11th Cavalry and the 76th Field Artillery. No improvements were made until 1938 when permanent buildings were constructed. In August 1940, Camp Ord was designated Fort Ord and the post was expanded to more than 20,000 acres. During World War II, the post was a staging area for many fighting divisions and units. Following World War II, the post was the home of the 4th Infantry Division which trained soldiers for the Korean conflict. In 1957, Fort Ord was designated U.S. Army Training Center, Infantry. During the early 1960's, Fritzsche Army Airfield (FAAF) was completed. In 1974, the training center was deactivated and the 7th Infantry Division occupied the installation. In July 1991, the BRAC Commission recommended that Fort Ord be closed and that the 7th Infantry Division be moved to Fort Lewis. In FY90, a Preliminary Assessment and Site Inspection (PA/SI) identified 61 sites at the installation. Among these sites was the 8,000-acre impact area. Fort Ord is scheduled for closure under the BRAC.

2.3.4 Future Land Use Plans

The MRA, including ranges 18 through 48, comprises approximately 8,000 acres located in the southwestern portion of former Fort Ord. Approximately 7,000 acres of the MRA

fall within the natural resource management area. BLM will manage the area by controlling public access. The remaining portion has been slated for urbanized redevelopment under the Fort Ord Base Reuse Plan.

The U.S. Department of the Army and the U.S Bureau of Land Management (BLM) have signed a Memorandum of Understanding (MOU) that outlines the terms and conditions for the transfer of properties located at the former Fort Ord. The MOU requires the development of a Site Use Management Plan (SUMP) for the MRA. The SUMP will provide a general description of the site and addresses proposed future land use. In general, the SUMP describes the current ordnance-related hazards and demonstrates how planned reuse can most effectively be achieved. The MOU states the purpose of the SUMP as follows:

> The SUMP shall delineate areas of high, medium and low UXO occurrence. Within area of medium or low occurrence, the SUMP shall identify (1) areas to be routinely occupied by BLM personnel; (2) the location of maintenance roads; (3) the location of firebreaks suitable for use by motor vehicles; and (4) the location of footpaths. The SUMP will be consistent with the HMP (habitat management plan), will be included as part of the Army's UXO clearance plan submitted to the Department of Defense Explosive Safety Board (DDESB), and will be considered in decisions regarding UXO made under applicable environmental laws and regulations.

Planned reuse is partly dictated by the presence of UXO. Because of the presence, type, and quantity of UXO on the property, Army and BLM agree that some areas may not be cleared. In uncleared areas, future land use will be restricted. Clearance of these areas is currently considered cost-prohibitive. The intent of the proposed reuse is to allow for implementation of the HMP and compatible public use.

2.3.5 Statement of Work

Human Factors Applications, Inc. (HFA) was under contract to the U. S. Army Corps of Engineers, Huntsville Division (CEHND), Huntsville, Alabama, to provide UXO services for Fort Ord. The objective of this contract was to provide OEW sampling operations to ascertain the presence or absence of UXO.

This sampling operation was conducted in two phases: Grid and Boundary Location Survey Phase and UXO Surface/Subsurface Sweep and Characterization Phase.

The objective of the Grid and Boundary and Boundary Location Survey Phase was to locate and mark the location of each grid and establish the boundaries of each site identified. The survey was to establish the location of sampling grids in each site. The survey was conducted by two teams of HFA personnel using standard military grid maps; the site grid coordinates were provided in the OEW Archives Search Report (ASR). The

teams were augmented with portable Global Positioning Systems (GPS) to provide an added degree of accuracy and efficiency. Using the grid coordinates and the site description provided in the ASR, the survey team located and marked the center of the site. The outer boundaries of the site were then located and marked using the grid coordinates developed by HFA.

The UXO Surface/Subsurface Sweep and Characterization was conducted using magnetometry and geophysical searches. All grids received a 100% subsurface search using government-furnished Schonstedt Model GA-72CV Magnetometers. Contacts and anomalies were marked with yellow flags for excavation and identification.

Table 2-1. Summary of DoD sites reviewed in detail.

State and site	FUDS/ BRAC	Similar topography	UXO/OE - pre-1970 era	UXO/OE - post-1970 era	ROD or EE/CA	Turned over to public	Notes & Land Use
ARIZONA							
Yuma Auxiliary Fields	FUDS	YES	YES	NO	NO	YES	Property is now used for agriculture and housing developments.
CALIFORNIA							
Camarillo Airport (Oxnard AFB)	FUDS	NO	YES	NO	NO	YES	Part reacquired due to OEW being found. Facility is a public airport.
East Elliot	FUDS	YES	YES	NO	YES	YES	Residential.
Former Camp San Luis Obispo	FUDS	NO	YES	NO	NO	YES	9159 acres FUDS, 5400 acres still active. Uses are agriculture, residential, parks, and prison.
Fort MacArthur	FUDS	YES	YES	NO	YES	YES	ROD. Park.
Mission Trails	FUDS	YES	YES	NO	YES	YES	Park.
Tierrasanta Community at Camp Elliott	FUDS	YES	YES	NO	YES	YES	Open space.
Wiley Well Water Point	FUDS	YES	YES	NO	NO	YES	BLM and prison.
Fort Ord	BRAC	YES	YES	YES	YES	PARTIAL	Residential, recreation.
COLORADO							
Former Fort Carson	FUDS	NO	NO	NO	NO	YES	No live ammunition ever allowed. National forest, Cheyenne Mountain Complex, private property.
KANSAS							
Former Fort Mason (Kansas Army Ammunition Plant)	FUDS	NO	YES	YES	NO	PARTIAL	Still manufacturing some munitions. Part of property used for grazing inside of plant boundaries; farming outside boundaries.

State and site	FUDS/ BRAC	Similar topography	UXO/OE - pre-1970 era	UXO/OE - post-1970 era	ROD or EE/CA	Turned over to public	Notes & Land Use
Independence Army Air Field	FUDS	NO	YES	NO	NO	YES	Airport, business park, farming.
NEBRASKA							
Former Nebraska Ordnance Plant	FUDS	YES	YES	NO	YES	YES	Agriculture and livestock research, private property, Army reserve, National Guard.
NEW MEXICO							
Kirkland Air Force Base	FUDS	YES	YES	NO	NO	YES	Shooting park, airport, national park.
OKLAHOMA							
Camp Gruber Military Reservation	FUDS	YES	YES	NO	NO	YES	
OREGON							
Umatilla Depot	BRAC	YES	YES	NO	YES	NO	
SOUTH DAKOTA							
Former Black Hills Army Depot	FUDS	YES	YES	NO	YES	NO	
TEXAS							
Bluebonnet Ordnance Plant	FUDS	YES	YES	YES	NO	PARTIAL	Contractor still manufactures rocket motors in half of property; agriculture, residential, park in other half.
Camp Fannin	FUDS	YES	YES	NO	NO	YES	Agriculture, industrial park.
Former Pampa Army Airfield	FUDS	YES	YES	NO	NO	YES	Agriculture.
UTAH							

State and site	FUDS/ BRAC	Similar topography	UXO/OE - pre-1970 era	UXO/OE - post-1970 era	ROD or EE/CA	Turned over to public	Notes & Land Use
Hurricane Mesa Test Site	FUDS	YES	YES	NO	NO	PARTIAL	BLM, state land, test track leased to contractor.
South Triangle	FUDS	YES	YES	NO	YES	NO	CWM area.
Yellow Jacket Target Area	FUDS	NO	YES	NO	YES	NO	CWM area.

3.0 DEPARTMENT OF ENERGY CLEANUPS

All Department of Energy (DOE) facilities with either UXO or OE contamination are identified below for potential applicability to INEEL and as a reference for UXO/OE problems across the DOE complex. Table 3-1 (at the end of this section) summarizes information about each facility.

3.1 Nevada Test Site

3.1.1 Site Description

The Nevada Test Site (NTS) is located in southern Nevada, about 65 miles northwest of Las Vegas. The site occupies 1,350 square miles. Since its establishment in 1950, the primary mission of the NTS has been to conduct field testing of both nuclear and conventional explosives in connection with the research and development of nuclear weapons. In addition to weapons testing, the site also hosted numerous secondary missions, including: open-air nuclear reactor, nuclear engine, and nuclear furnace tests; hazardous materials spill response testing; and experiments involving radioactive and nonradioactive materials.

3.1.2 Regulatory Drivers

Area 27, located at the center-southern boundary of the NTS, was an Explosive Ordnance Disposal Treatment Unit used from about 1960 until November 1992. The site consists of a burn pit, explosion pit bore holes, and a personnel protection/control bunker. In preparation for site remediation, environmental specialists developed a closure plan in accordance with the Resource Conservation and Recovery Act (RCRA). The State of Nevada Division of Environmental Protection is the regulating agency that approves the plan and seeks public comments. A major effort identified for the cleanup is to identify, remove, and dispose of contaminated soil. The site is being restored under the Streamlined Approach for Environmental Restoration, or SAFER. Under this process, a key component is creating and validating assumptions about a particular site. One key assumption made is that clean closure may be a practical remediation alternative. Under clean closure, there is a small likelihood of residual wastes or hazardous constituents remaining after the site is closed. Samples will be collected and analyzed to determine if constituents of concern are present and in what concentrations. If the samples taken contain metals and organic compounds above acceptable regulatory standards, the soil will be removed and stored on-site or at a commercial facility. Soil excavations are expected to be about 1 foot deep. Additional soil samples will be taken after the soil is removed to validate the site can be closed. The remediation of this project is expected to take several months to complete.

3.1.3 Future Land Use Planning

Like the INEEL, future land use planning at the NTS has not been finalized. The Baseline Environmental Management Report (BEMR) includes the following regulatory issue:

> State officials contend that any final strategy to address surface soil contamination at the Nevada Test Site must be developed in the context of future land uses that embrace the concept of how clean is clean for what use. Department of Energy officials in Nevada are establishing an approach to embrace this concept by developing a site-wide Resource Management Plan as part of the Nevada Test Site, Site Wide Environmental Impact Statement.

The *Final EIS for the Nevada Test Site and Off-Site Locations in the State of Nevada; Volume 2 Framework for The Resource Management Plan, August 1996* publicizes how the DOE Nevada Operations Office proposes to develop and use a *Resource Management Plan* which will lead to establishing future land use. Since the NTS has some similarities to INEEL including similar topography, contaminants, and stakeholders such as Native Americans, the land use process at NTS could provide INEEL with a model to emulate.

3.2 Sandia National Laboratories

3.2.1 Site Description

The Sandia National Laboratories Site is located in central New Mexico on Kirtland Air Force Base, just south of Albuquerque. The site occupies 2,820 acres. The site was established to conduct research and development in the interest of national security, with emphasis on nuclear weapons development and engineering. Past firings conducted to test weapons and weapons components have contributed to the contamination of facilities, soils, and groundwater at the site. For the purposes of environmental restoration these areas have been grouped into four geographic areas: North Technical Areas, South Technical Areas, Firing Ranges, and the Thunder Range.

UXO/HE is present at 12 sites around the Sandia National Laboratory. Live ordnance was removed from nine sites, and the remaining sites await regulatory approval before removal and disposal can be completed. The UXO/HE found included high-explosive chunks, solid rocket propellant, bomb fuses, five-inch shells, flares, booby traps, flash and smoke grenades, and rocket motors.

The Sandia National Laboratory has potential for applicability to INEEL since the site is currently in the assessment phase and Remedial Action Objectives have not been established.

3.3 Pantex Plant

3.3.1 Site Description

The Pantex Plant Site is located in the Texas panhandle, about 17 miles northeast of the City of Amarillo. The site covers about 16,000 acres. The Plant was built by the U.S. Army in 1942 as a conventional bomb plant. In the 1950s, the plant was modified to manufacture high explosives used in nuclear weapons and for the final assembly of nuclear weapons. During the mid-1960s, the plant's mission was expanded to include maintaining and evaluating nuclear weapons in the stockpile and dismantling nuclear weapons as they are retired from the stockpile. Past production activities at the plant have resulted in the contamination of soils and possibly the groundwater with hazardous materials. The Pantex Plant was placed on the EPA NPL on May 31, 1994.

Numerous sites exist at the Pantex Plant where the primary contaminants of concern for the soils and also in the perched groundwater are HE products, such as RDX and HMX. No UXO is suspected to exist at this site.

3.3.2 Preliminary Remediation Goals for OE

DOE has published the *Pantex Plant Amarillo, Texas, Final Risk Reduction Rule Guidance For Pantex Plant RCRA Facility Investigations*. This is a final draft and was prepared by Mason & Hanger Corporation/Battelle Pantex in August 1996. This document is the first attempt by the DOE at Pantex Plant to 1) provide a common data source for properties of all potential contaminants anticipated at Pantex Plant 2) present an integrated approach for calculating media PRGs (Preliminary Remediation Goals) for potential contaminants identified in each site-specific RFI (RCRA Field Investigation); and 3) provide a dynamic guidance document for the DOE and its contractors for use in conducting RFIs and corrective action at Pantex Plant. This document contains a *Nonresidential Use Surface Soil, Subsurface Soil, and Groundwater PRGs* Table. Screening concentrations from this document are included in Section 5.2 of this report and may be useful in determining cleanup of TNT- and RDX-contaminated soils at INEEL. The complete document is provided in the reference documents of this report.

3.4 Tonopah Test Range

3.4.1 Site Description

The Tonopah Test Range is located in southern Nevada on the Nellis Air Force Range, about 150 miles northwest of Las Vegas. The area is a research facility with the mission to test the mechanical operation and delivery systems for nuclear ordnance and other defense-related projects. The site was used to test ordnance delivery systems employing mock-ups of nuclear weapons, and tests with conventional explosives. Since 1956, the Tonopah Test Range has been managed by the DOE and its predecessors under a Memorandum of Understanding with the U.S. Air Force. The site is still actively used by

Sandia National Laboratories and the U.S. Air Force. During a five-month UXO cleanup project, several thousand bomblets and 150 larger practice bombs and artillery shells were detonated and disposed of safely. Nearly 400 spent rocket motors were cut up as scrap and more than 120 tons of scrap steel and five tons of scrap aluminum were recycled. All six sites are "free of ordnance and debris"; three of the sites are ready for site characterization work, and the other three require surface soil sampling to verify that contaminants have been removed.

3.4.2 Regulatory Drivers

UXO was removed from five sites at the Tonopah Test Range. The five sites were addressed in a *Voluntary Corrective Action (VCA) Work Plan for Ordnance Removal from Five Disposal Sites at the Tonopah Test Range, January 1995.* The focus of the VCA is the removal of UXO and debris from the five sites to allow closure at a later date. Once the removal of UXO was complete, the sites would be declared free of UXO and verification sampling would take place to confirm that no RCRA regulated substances remain.

3.4.3 Remediation Methods

One notable aspect of the UXO cleanup at TTR was the use of the Sandia National Laboratory RETRVIR system in the Bomblet Pit. The RETRVIR system uses a remote-control manipulator arm and various system mounted, real time video cameras to locate and pick up individual bomblets. Section 3.0 of the reference volumes contain the above referenced VCA and also *the Safety Assessment for Ordnance Removal from Five Disposal Sites at the Tonopah Test Range,* January 1995. The final report for the corrective actions at TTR was not available at the time of preparation of this report.

3.5 Lawrence Livermore National Laboratory, Site 300

3.5.1 Site Description

Site 300 of the Lawrence Livermore National Laboratory (LLNL) is located in Northern California, approximately 15 miles southeast of the Laboratory's Main Site and 10 miles southwest of the City of Tracy. The site occupies 11 square miles. Site 300 was purchased from local ranchers in the 1950s. The site's former and current mission is the research and testing of non-nuclear high-explosive components for the DOE nuclear weapons program. Explosive materials have resulted in soil and groundwater contamination at the site. Since military munitions were not tested at this site, no UXO exists.

Environmental Restoration personnel at LLNL have stated that soil concentrations of high explosive residues are very low and there is no plans for cleanup. Information regarding contaminant types, soil concentrations and action levels at this site have been requested but has not been received.

3.6 Weldon Spring DOE Site

3.6.1 Site Description

The Weldon Spring DOE Site is located in Eastern Missouri, about 30 miles west of St. Louis. The site occupies 229 acres. Weldon Spring was part of a site used by the U.S. Army as an ordnance works in the 1940s. In the 1950s and 1960s, the Atomic Energy Commission used the site for processing uranium ore in the Weldon Spring Chemical Plant. In addition the Weldon Spring Ordnance Works produced TNT. The plant was subsequently deactivated, and no activities have been carried out at the site until remediation was undertaken. The Weldon Spring Site was placed on the Environmental Protection Agency National Priorities List on March 13, 1989. Areas of the Weldon Springs Site are being investigated and remediated by DOE. In 1988 cleanup investigations were conducted at the chemical plant and raffinate pits area, and since that time a number of cleanup actions have been under taken to stabilize the site and to reduce offsite migration of contaminants. Removal of bulk waste from the quarry began on May 27, 1993. In November 1995, after removing over 120,000 cubic yards of contaminated waste, the quarry bulk waste removal activity was declared substantially complete.

The Weldon Spring site has little, if any, applicability to INEEL. The Record of Decision documents the selection of "bulk removal" of contaminants and does not provide specific cleanup concentrations.

3.7 Los Alamos National Laboratory

3.7.1 Site Description

The Los Alamos National Laboratory (LANL) is located in north-central New Mexico, about 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. The site occupies about 43 square miles. LANL was established in 1943 for the design, development, and testing of nuclear weapons. Supporting this mission were research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology.

Environmental Restoration at LANL is subdivided into field units, which are generally defined geographically with some functional distinctions. There is a total of six units at the LANL facility. Of these field units, only Units 2, 3, 4, and 5 have high-explosive contamination. Operable Unit 1093 is located in Field Unit 2 at LANL and was used for implosive testing of high explosives used in the atom bomb. In addition this area was used by the U. S. Army as an impact area for the bazookas firing. The hazard at this site was unexploded ordnance and fuses buried in the soil and undetonated HE on ordnance fragments and in the soils

3.7.2 Regulatory Drivers

Cleanup authority at LANL is carried out under the Laboratory's State of New Mexico's RCRA operating permit and consists of Corrective Actions. LANL is currently in the assessment phase until FY 2002.

3.7.3 Lessons Learned

A lesson learned was that the large quantity of ordnance debris at OU 1093 prompted a departure from the site work plan which only specified an investigation to be conducted. Due to the wide dispersion of the debris and UXO, it was determined that it was impractical to mark and map each fragment rather than simply removing it when found. Therefore UXO was removed as part of the investigation effort both as a more practical way to deal with the UXO when found rather than returning a second time to remove the debris. Also removal of the debris during excavation allowed for follow on surveying and Phase two remediation of contaminated soils to proceed with greater safety. This methodology was also employed at 4 other solid waste management units within Operable Unit 1071.

3.7.4 Remedial Action Objectives

LANL is attempting to achieve clean closure of it UXO sites by making the following statement in the *RFI Phase Report, Operable Unit 1071, SWMU Aggregate 0-D, Ordnance Impact Areas, March 1994:*

> Given the extremely thorough UXO and OEW search and removal operation and absence of any significant contaminants in the search and removal operation and absence of any significant contaminants in the soil or sediments, it is recommended that the site be designated as a NFA (No Further Action) PRS (Potential Release Site) and be approved for residential land use.

UXO Sites at LANL have as yet to be clean closed and released back to the public; however if using the above argument results in acceptance by stakeholders, it could well be very applicable for sites at the INEEL.

Table 3-1. Summary information on DOE sites.

Sites Administered by the Department of Energy	FUDS/ BRAC	Similar TopographHy	UXO/OE - Pre-1970 Era	UXO/OE - Post-1970 Era	ROD or EE/CA	Returned for Public Use	Notes
Lawrence Livermore National Laboratory, California	No	No	Yes	Yes	No	No	Ordnance Explosive Wastes Only Not much applicability to INEEL
Weldon Spring, Missouri	Yes	No	Yes	Yes	Yes	Partial Return	Ordnance Explosive Wastes Only Not much applicability to INEEL
Nevada Test Site, Nevada	Yes	Yes	Yes	Yes	RCRA Closure Plans Requested	No	Ordnance Explosive Wastes and Radioactive Contaminated Soils. No UXO.
Tonahah Test Range, Nevada	Yes	Yes	Yes	Yes	Requested	No	Applicability to INEEL both with Ordnance Explosives and UXO. Removal of UXO before RCRA closure activities.
Los Alamos National Laboratory, New Mexico	Yes	Yes	Yes	Yes	No	No	LANL is still in preliminary assessment phase of RCRA RFI investigation. UXO removed during investigation phase.
Sandia National Laboratory, New Mexico	No	Yes	Yes	Yes	RCRA Closure Plans Requested	No	Sandia has potential applicability to the INEEL both for UXO and OE. Information has been requested from technical personnel.
Pantex Plant, Texas	Yes	Yes	Yes	Yes	RCRA RFI in Progress	No	Pantex Plant has soils contaminated with TNT and RDX similar to INEEL. No UXO present.

4.0 MISCELLANEOUS CLEANUPS

4.1 Commercial Cleanups

Commercial cleanups found across the United States mostly include facilities that manufactured munitions and explosives for both the military and civilian use. Olin Arms, Winchester, and Hercules are a few of these companies. The facilities are often associated with industrial areas that were in close proximity to urban populations as opposed to FUDS that did weapons or ordnance testing and were for the most part remote. Table 4-1 (at the end of Section 4) summarizes these sites and information pertinent to the INEEL.

There are two factors that are inherent in a commercial cleanup that make it difficult to apply to the INEEL. First, due to the growing and expanding nature of America's urban areas, what were once industrial areas are now being turned over to private real estate developers for residential development. Cleanup is then driven both by public concerns of safety and the need to eliminate deed restrictions so that property values are not affected by the potential to encounter a piece of UXO. As the value of the property these facilities reside on increases, facilities owners are turning to cleanup so that the property can be sold for the highest possible value. Cleanup also is necessary to reduce potential future liabilities. Second, these "private" funded cleanups are generally done in association with a local or state agency oversight. EE/CAs and RODs are not produced and therefore details are not part of the public record. Most often the private owners hire UXO companies directly and the cleanup information and costs are proprietary, making them difficult or impossible to obtain.

4.2 Aerojet Ordnance, Chino Hills, California

The Aerojet Ordnance Manufacturing Facility located in Chino Hills, California, is a case in point. This facility manufactured cannon ammunition (high explosive and depleted uranium), high explosive projectiles, and submunitions. This facility is currently in the process of being deactivated and divided into parcels to be sold. Plans were developed to build two golf courses and a community center on the property. The property surrounding this facility is owned by private parties. The privately owned property had been under lease to Aerojet to act as a buffer from a rapidly developing community. As the leases came closer to renewal, Aerojet decided these areas were in need of subsurface searches so they could be returned to the owner and eventual sale to the public. This follow-on action was started in February 1995 and is still ongoing.

The first ordnance removal action started on this property in July 1994 with McClaren Hart as the design contractor and Wyle Laboratories supplying the ordnance removal personnel. The area approached first was the old disposal area. This area was remediated using a mechanical conveyor screen that sorted materials down to ½-in. diameter for visual inspection and removal of UXO and OE.

No costs or specific cleanup information is available since all information is considered proprietary by Aerojet and will not be released by Wyle, the cleanup contractor.

4.3 Other Government Agency Cleanups

Lands administered by other government agencies, such as the Department of Agriculture, Department of Interior, and the Bureau of Reclaimation, occasionally must deal with UXO and OE. Generally, the incidence of UXO and OE is in association with a FUDS and the DoD then becomes involved both as a funding agency for the cleanup and as the center of expertise for methods of cleanup and safety standards. While other agencies may procure and administer the services of cleanup contractors, if military ordnance is involved, USACE oversight is often present.

There may be some applicability to the INEEL of cleanups administered by other government agencies. Currently, at the INEEL, ordnance testing at the NPG was not confined to the INEEL boundaries. Naval munitions are present on the southern-most boarder of the INEEL and extend onto lands administered by the BLM. It is undetermined which government agency will have responsibility for the assessment and cleanup of this area at this time; however, there is precedence where the BLM has been involved in cleanup of UXO and OE. Three cases in point exist:

4.4 Boise Hills Fire

First, in the summer of 1996, a wildfire in the hills above Boise, Idaho stripped much of the vegetation from the watershed that controlled water runoff into the north and eastern sections of Boise. With the threat of mud slides and flooding due to the coming fall and winter precipitation, the BLM began a massive effort to prevent uncontrolled runoff by using equipment and hand tools to terrace the hills in the watershed catchment. Work was haulted on this critical project when UXO was discovered in several locations. The ordnance was present as a result of WWII-era training exercises carried out by a local Boise reserve unit. Artillery rounds and rifle grenades were of most concern. Work was allowed to begin again after the USACE inspected the site and determined that the immediate risk to workers was acceptable; however, the BLM is faced with a future cleanup of this very popular recreational area. Literally thousands of Boise residents use the hills each weekend for jogging and motor biking. No cleanup standards have yet been established, but the high recreational land use of most of this area and potential for residential expansion in the area above Old Fort Boise will likely drive an aggressive cleanup.

4.5 Monite Explosives Facility

Second, BLM was involved in conducting the Non Time Critical Removal Action conducted just outside the city of Sparks, Nevada. The site is the location of the former Monite Explosives Facility that manufactured explosives like TNT from the 1930s until 1955. An EE/CA was prepared for this site for the BLM.

The removal action objectives were designed to minimize the actual or potential threat to nearby human populations from the contaminants present in surface soils at the site and to minimize the potential for the contaminants to migrate. Chunks of TNT and DNT were discovered by local children. Also, an irrigation ditch and potable water wells in the area were considerations in establishing the removal action objectives.

4.5.1 Cleanup Standards

There is some applicability to the INEEL in the methods used by the BLM to establish the areas to be cleaned up at this site and the cleanup standards chosen. Cleanup involved both soil excavation, mechanical screening with visual inspection for TNT and DNT chunks down to ½-in. in diameter, and removal of the contaminated soils for incineration. *Surfer* for Windows was used to aid in interpreting the sampling results. Contour gridding of screening data concentrations (TNT/DNT) from over 300 sample locations over the 7-acre site from depths up to 4 ft was performed using kriging algorithms. The contouring from this modeling developed a theoretical limit of the areas at various depth intervals for material exceeding the various potential action levels.

Removal quantities were determined based upon screening results, which are not compound-specific. In determining the quantity, it was assumed that the screening data represented only 2,4-dinitrotoluene, which has the most conservative cleanup level (proposed @ 6.6 mg/kg). A mathematical relationship between total 2,4-dinitrotoluene concentrations (USEPA Method 8330 data) and the corresponding Toxicity Characteristic Leaching Procedure (TCLP) concentrations indicated that soils with a total 2,4-dinitrotouene concentration above 8 mg/kg would be classified as exhibiting the RCRA characteristic of toxicity (>0.13 mg/kg).

The amount of soil requiring removal was determined utilizing *Surfer* for Windows contouring and volumetric package as well as professional judgment. The contaminated soil above the proposed cleanup goal (6.6 mg/kg) was estimated to be 1,056 cubic yards (in situ). Preferred Alternative selection was not finalized in the EE/CA but was held off until after a Request for Proposal was put out to bid and the BLM reviewed costing of various options included in the RFP. Three separate bioremediation options for the TNT/DNT-contaminated soils were deemed to be too expensive, and transportation to an offsite incinerator was chosen. More detailed information for this Removal Action is found in U.S Department of the Interior Bureau of Land Management's *Draft Engineering Evaluation/Cost Analysis Report*, July 17, 1995, which is included in the reference volumes of this report.

4.6 Garfield Flats Test Range

Third, BLM was involved in the Garfield Flats Test Range cleanup. Garfield Flats is located northwest of Tonapah, Nevada. Approximately 640 acres of BLM land received ordnance from a missed quality assurance ordnance test at the Garfield Flats Test Range

run by Olin Ordnance. The land use was unrestricted recreational, and there was also a concern for wild horses that were indigenous to the area. BLM chose not to do a subsurface cleanup based on this land use and only the surface was cleared. Visual searches were conducted in areas where brush was not present; however, approximately 248 acres were gridded off in 5-ft lanes and searched with magnetometers. Only surface ordnance was removed.

Table 4-1. Summary information on miscellaneous sites.

Miscellaneous Commercial and CERCLA Sites	FUDS/ BRAC	Similar Topography	UXO/OE - Pre-1970 Era	UXO/OE - Post-1970 Era	ROD or EE/CA	Returned for Public Use	Notes
Hastings Groundwater Contamination Site, Adams County, Nebraska	Yes	No	Yes	No	ROD	No	The Hastings site contains TNT contamination. The ROD specified cleanup goals for surface soils for TNT was 2.5 mg/kg; concentrations exceeding 660 mg/kg (carcinogenic risk >10-4) to be incinerated.
Roebling Steel Company Burlington County, New Jersey	No	No	Yes	Yes	ROD	No	Explosive Wastes were contaminants of concern however the presence of lead was the risk driver. Not applicable to INEEL.
Chemtronics Inc. Buncombe County North Carolina	No	No	Yes	Yes	ROD	No	Explosive wastes were burned on site. Other contaminants risk drivers. Not applicable to INEEL.
Bangor Naval Submarine Base	Yes	No	Yes	Yes	ROD	No	This site while a former DoD site was remediated under CERCLA. The ordnance explosive wastes were not risk drivers and there appears to be no application to the INEEL OU 10-03.
Aerojet Ordnance Manufacturing Plant Chino Hill, California	No	No	Yes	Yes	No	Partial	Site cleanup conducted by property leasee prior to return to owner for commercial development. Cleanup information proprietary.
Boise Hills Fire, Boise Idaho	Yes	No	Yes	No	No	Currently unrestricted Public Access	Site of former WW II era artillery and training range. Recent discovery of UXO may drive expedited cleanup. No current applicability to the INEEL.
Monite Explosive Plant Sparks, Nevada	No	Yes	Yes	No	EE/CA	Remediation underway	This site being remediated under the administration of the BLM. EE/CA risk contoured screening approach for removal of TNT contaminated soils.
Garfield Flats Nevada	No	Yes	Yes	Yes	No	Unrestricted Recreational	Site used for recreation and mining. BLM administered surface only cleanup.

5.0 UXO IDENTIFICATION AND FIELD SCREENING

5.1 UXO Identification Techniques and Procedures

Unexploded Ordnance/Ordnance and Explosive (UXO/OE) remediation activities across the country have been quite standardized throughout the years. Historically, the remediation techniques and procedures have consisted primarily of searching a suspected designated area by establishing grids. These grids are normally 100 feet wide and vary in length from 100 feet to whatever distance the terrain permits. These established grids are then broken down to 5-foot lanes. The lanes are then "swept" by UXO personnel utilizing hand-held magnetometers to locate and mark the geophysical anomalies.

The U.S. Army Ordnance and Explosives Center of Expertise and Design has recently identified the best hand-held, analog-output, geophysical instruments available and directed **only they** be used in OE field Quality Assurance These instruments were the Schonstedt 52-cx, Magnatrak 102, and the Foerster Mk 26. The most commonly used instrument for this is the Schonstedt 52-cx.

Even with these instruments, two significant problems are encountered: (a) location and (b) identification of geophysical anomalies without having to excavate every anomaly identified with the magnetometers.

For the location problem, the latest and most highly rated magnetometers available today are the time-domain EM-61 and the Geometrics G-858 dual-sensor cesium magnetometer. Both of these instruments were tested in July 1995 at the Jefferson Proving Grounds (JPG) in Madison, Indiana (see NOTE below). They located 85% and 83% of the items, respectively, (on a known 40-acre "seeded" site). Both of these magnetometers readily detect the geophysical anomalies, but the EM-61 indicated 23% more false targets than the G-858.

For the identification problem, computer software is available to help eliminate the non-UXO items these instruments indicate. S. Cohen & Associates (SC&A) of McLean, Virginia, has been contracted by the U.S. Corps of Engineers (USACE) to develop an Ordnance and Explosive Knowledge Base (OE-KB). Geometric, Inc., of Sunnyvale, California, has a program called MagAID. These programs are based on magnetic pattern-matching algorithms, using a maximum-likelihood estimator approach. The MagAID program is currently available in its present form. While work continues, these programs do not now provide significantly better accuracy than traditional technologies and techniques.

In conclusion, while new instruments and techniques are being developed, UXO/OE remediation at the INEEL will be most efficient and cost-effective via traditional methods that use standard hand-held magnetometers for locating geophysical anomalies, that is, the standard "Mag" and "Flag" clearance of UXO/OE.

NOTE - The abstract below from the Institute for Defense Analyses (IDA) was reported in their *IDA Research Summaries*, Spring/Summer '95, "The Legacy of Unexploded Ordnance":

> Using current techniques, which are labor-intensive and hazardous, the estimated cost of clearing UXO from U.S. land is in the hundreds of billions of dollars. The Congress mandated funds for a UXO technology demonstration to be conducted at the Jefferson Proving Ground in Indiana. The objective was to identify and evaluate innovative and cost-effective systems for the detection, identification, and remediation of sites contaminated with unexploded ordnance. IDA conducted a series of detailed technical evaluations for this program. These efforts highlighted issues related to system performance, assessed the applicability of the results to other contaminated sites, determined the implications for past and future cleanup efforts, and evaluated the technical requirements of future research and development activities. Our general conclusion was that operationally, the demonstrated level of performance at Jefferson Proving Ground was not adequate to deal effectively with land contaminated with UXO. The Department of Defense has responded by expanding efforts to address this problem and continues to turn to IDA for technical expertise.

(IDA is a nonprofit corporation whose purpose is to promote national security and the public interest and whose primary mission is to assist the Office of the Secretary of Defense, the Joint Staff.)

5.2 Risk-Based Concentrations for Ordnance Explosives

While risk-based concentrations for OE such as TNT and RDX vary based on future land use assumptions, two of the sources of information obtained during the search for Remedial Action Objectives and Preliminary Remediation Goals may have the most applicability to the INEEL.

First, Table 5-1 (at the end of Section 5) presents EPA Region 10's screening values for soil based on the conservative residential scenario. Both the cancer risk and the toxicity Hazardous Quotient must be considered for most OE. EPA Region 10 uses the default depths of 1-2 ft for recreational and grazing land use; 4 ft for industrial land use, and 10 ft for residential land use.

Second, the Texas Natural Resource Conservation Commission (TNRCC), which oversees the Environmental Restoration of the Pantex Plant, has published final Risk Reduction Rules, Title 30, that allow risk-based cleanup standards to be established and used as Preliminary Remediation Goals (PRGs) during site remediation. These PRGs were developed only to address the human health risk factors and do not consider other ecological receptors and endpoints. DOE proposes to use the TNRCC standards as the basis on which the extent of acceptable residual contamination is determined. These

PRGs are presented in Table 5-2 (at the end of Section 5). The table presents the calculated nonresidential use PRGs for surface soil (further differentiated into drainage, uplands and playas) and subsurface soils. Table 5-2 only presents information applicable to OE at the INEEL. The complete table is contained in *U.S. DOE Pantex Plant Amarillo, Texas Final Risk Reduction Rule Guidance for Pantex Plant RCRA Facility Investigations, August 1996.* This document is included in the Pantex section of the reference volumes that accompany this report.

5.3 Field Sampling for Ordnance Explosives

A recently published EPA Issue Paper has applicability to characterization of the TNT- and RDX-contaminated soils at the INEEL. The paper, *Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil; December 1996,* discusses the usefulness of On Site Analysis Methods and modifications to past on-site methods which may improve characterization performance. The paper states: "On-site analytical methods are essential for more economical and improved characterization, and what they lack in accuracy relative to laboratory methods, is more than offset by the increased number of samples that may be run".. The paper includes a table titled "Comparative Data for Selecting On-Site Analytical Methods for Explosives in Soil", which includes a list of commercially available Test Kits and specifies types of contaminants and detection ranges. The Issue Paper is included in the reference volumes that accompany this report.

Table 5-1. Risk based concentrations / ordnance materials.*

ORDNANCE COMPOUNDS	RISK - 10 6 (mg/kg)	RISK - 10 4 (mg/kg)	HQ - 1 (mg/kg)	TRD (ORAL)	SOURCE	SLOPE FACTOR (ORAL)	SOURCE	CANCER WOC
1.3 DINITRODENZENE	NA	NA	30	1.0E-04	IRIS	NA	-	D
1.3.5 TRINIBROBENZENE	NA	NA	10	5.0E-05	IRIS	NA	-	D
2.4 DINITROTOLUENE (DNT)	0.9	90	500	2.0E-03	IRIS	6.0E-01	IRIS	82
2, 6 DINITROTOLUENE	0.9	90	300	1.0E-3	MEMO 11/91	6.0E-01	IRIS	82
HMX (OCTAHYDRO-1.3.5.7-TETRANITRO-1.3.5.7-TETRAZODINE	NA	NA	10,000	5.0E-02	IRIS	NA	-	D
NITROBENZENE	NA	NA	100	5.0E-04	IRIS/HEAST	NA	-	D
PICRIC ACID	NA	NA	600	3.0E-03	MEMO 6/92	NA	-	-
PICRAMIC ACID	NA	NA	500	2.0E-03	MEMO 6/92	NA	-	-
PGON (1, 2-Propyiene glycol dinitrate) Otto fuel	NA	NA	NA	NA	NA	NA	-	D
RDX (Hexahydro-1,3,5-trinitro 1.3.5-trizine)	0	800	800	3.0E-03	IRIS	1.1E-01	IRIS	C
TETRYL	NA	NA	3000	1.0E-02	MEMO 11/91	NA	-	D
2,4,6-Trinitrotoluene (TNT)	20	2000	100	5.0E-04	IRIS	3.0E-02	IRIS	C

*Screening values for soil based on ingestion, residential scenario; source is EPA, Region 10, 4/94.

Table 5-2. Preliminary Remediation Goals (PRGs) - nonresidential use surface soil, subsurface soil*

POTENTIAL CONSTITUENTS	SURFACE SOIL 0-2 ft (mg/kg)			SUBSURFACE SOIL 2-432 feet (mg/kg)
	DRAINAGE	PLAYA	UPLANDS	
cyclo-tetra methylene tetranitramine (HMX)	511	511	511	511
cyclo-trimethylene trinitramine (RDX)	2.6	2.6	2.6	2.6
2,4-dinitrotoluene (DNT)	20.4	20.4	20.4	20.4
2,4,6-trinitrotoluene (TNT)	5.1	5.1	5.1	5.1

* PRGs based on risk reduction standards 1 and 2 for Pantex Plant RCRA Facility Investigations.

6.0 CHARACTERIZATION AND REMEDIATION COSTS COMPARISON

Because of its sensitive and proprietary nature, complete information is not fully available for most actual costs to compare work at sites; this is true for those sites previously identified in this report. Even if the data was available, it is unlikely that it would be of much use in regards to the INEEL (or any other particular site). This statement is based on the cost information and studies done on past cleanups. This experience has shown that, depending on the identified site, UXO/OE remediation could take from several hours per acre to several days and resulting cost differences could be 400 times as expensive.

In terms of actual costs, Betty Neff, Huntsville Center Engineering Directorate, recently wrote an article titled "Getting Our Money's Worth: Removal Actions". She comments that most Defense Environmental Restoration Program (DERP) dollars go to removal actions. Based on data from nine projects, she states the cost per acre for a removal action ranged from $94 to $36,642, depending on the type of work required. (The average cost per acre for all nine was $4,006.) This range of time, and costs, can be demonstrated via work performed on the INEEL itself by comparing the 1994 interim cleanup actions between the TBBR and the NODA. The time to sweep one acre in the NODA was five times that of the TBBR. As with the wide variation in time and costs elsewhere, this is due to the extent of UXO/OE contamination and each identified or designated site not being properly or totally characterized. This problem is not unique to the INEEL. It is a nation-wide problem.

The most knowledgeable source on comparison of costs for UXO/OE characterization and remediation at this time is the U.S. Army Corps of Engineers (USACE). In April 1990, Huntsville, Alabama, was designated as the Mandatory Center of Expertise (MCX) and Design Center for all USACE activities involving OE. MCX is responsible for developing an overall framework for response for the OE program. Design center responsibilities included OE investigations and removal actions at Formerly Used Defense Sites (FUDS), active sites under the Installation Restoration Program, and Base Realignment and Closure (BRAC) sites. These programs were at first expected to be very limited in scope, as the FUDS inventory at that time had only a few hundred potential OE sites. However, there are now over 1800 potential OE sites on the FUDS inventory.

One of MCX's more noteworthy products of the technology program was the development of the Ordnance and Explosives Cost-Effectiveness Risk Tool (OECert). This model was developed by USACE and Quati Tech, Inc. for use in the defining of OE risk at FUDS. The model employs several factors (density of ordnance, type of ordnance, terrain features, population density, and many others) and can be put to several uses, including the following:

- Determine the site's risk to public safety.

- Develop rough order of magnitude life-cycle costs for the site (using many of these same factors, as well as other factors).

- Develop a prioritized work list for the FUDSs, as well as to perform prioritized work between different sub-sites of a site. The model will also assist the decisionmaker in performing cost/benefit tradeoffs. The prioritization list will be used to ensure that the work that will reduce public risk the most for each dollar spent will be performed first.

- Determine the inherent risk at a site.

- Determine when a site has been remediated to some previously specified level.

This program facilitates cost planning and aids in the formulation of remediation standards for all OE-contaminated sites. The OECert methodology is built around the exposure of the public to and the life cycle cost of the contaminated site through the phases of pre-remediation, remediation, and post-remediation. Site assessment must precede any meaningful assessment of cost-effectiveness. OECert prioritizes sites based on risk, cost, or cost-effectiveness ratio. Effectiveness is measured by the risk reduction that can be obtained through remediation of a site. Cost and risk reduction are dependent on a large number of variables. Cost, for prioritization purposes, is measured in constant-year dollars and includes the direct and indirect cost of remediation.